NEW ZEALAND AIRFIELD PAVEMENT SURFACE TYPES – EVALUATION, DESIGN, MAINTENANCE AND REHABILITATION

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ABSTRACT

New Zealand has a population of four million and has seven international airports and over 15 commercial regional airports. Typically the total number of annual aircraft movements is 1.2 Million with over 25 Million passengers per annum. New Zealand's climate is complex and varies from warm subtropical in the far north to cool temperate climates in the far south with severe alpine conditions in the mountainous areas, providing a range of challenges for airfield pavement design and maintenance.

The paper provides an outline of the airfield network, airfield pavement surface types and typical distresses observed in New Zealand and the maintenance treatments adopted. Airfield pavement projects undertaken in New Zealand over the last ten years total a construction value of over $250 Million. The projects have ranged from the reconstruction of the concrete runway at Auckland Airport; construction of new green field runways; runway extensions; night time asphalt runway and taxiway resurfacing works at both international and regional airports; new and reconstructed aprons with Portland Cement Concrete and Interlocking Concrete Block Paving and routine airfield pavement maintenance planning and construction works.

The paper provides examples of innovations and green solutions adopted on a number of civil and military airfield pavements in New Zealand, including under slab epoxy injection research and development; the use of recycled asphalt (RAP) in asphalt mixes; the recycling of crushed concrete and other aggregate substitutes and the use of low energy warm mix asphalt. It also features the conversion of a parallel taxiway to a temporary runway, together with examples of the collaborative approach adopted with a number of airport clients and contractors to achieve overall project objectives of safety, value for money, quality, environmental sustainability and on time delivery.

INTRODUCTION

New Zealand has a population of four million and has seven international airports and over 15 commercial regional airports. Typically the total number of annual aircraft movements is 1.2 Million with over 25 Million passengers per annum. A map of New Zealand showing the location of the main centres is shown in Figure 1 and the most recent annual aircraft movements summary is provided in Table 1. The seven international airports currently comprise Auckland, Hamilton, Rotorua, Wellington, Christchurch, Dunedin and Queenstown.

The relatively low population provides an associated challenge with the economic setting for the country and therefore the available funds for infrastructure investment. This together with the clean green image of New Zealand has led to a number of innovative and sustainable airfield pavement solutions that are described within this paper.

In addition New Zealand's climate is complex and varies from warm subtropical in the far north to cool temperate climates in the far south with severe alpine conditions in the mountainous areas, providing a range of challenges for airfield pavement design and maintenance.

Figure 1. Map of New Zealand showing main centres

Table 1.
New Zealand Aircraft Movements for 2009

Airport	Domestic IFR	Domestic VFR	International	Total
Auckland	106,459	7,494	41,967	155,920
Christchurch	76,544	48,436	11,247	136,227
Dunedin	12,891	40,323	388	53,602
Gisborne	10,803	13,152	0	23,955
Hamilton	27,508	120,515	357	148,380
New Plymouth	10,150	33,368	0	43,518
Napier	14,037	9,996	81	24,114
Nelson	21,301	26,971	1	48,273
Invercargill	7,150	18,648	7	25,805
RNZAF Base Ohakea	18,079	54,868	50	72,997
Palmerston North	19,321	39,432	8	58,761
Queenstown	7,918	37,251	797	45,966
Rotorua	9,482	11,231	21	20,734
Tauranga	11,433	85,711	0	97,144
Woodbourne/Blenheim	17,511	6,547	0	24,058
Wellington	87,164	18,856	5,922	111,942
RNZAF Auckland	6,216	6,765	239	13,220
Oceanic Overflights	0	0	7,282	7,282
Total	**463,967**	**579,564**	**68,367**	**1,111,898**

Source: Airways Corporation of New Zealand website www.airways.co.nz

TYPICAL NEW ZEALAND AIRFIELD PAVEMENT SURFACING TYPES

As background to this paper, this section outlines the various typical airfield pavement surface types found at New Zealand airports, the distress types associated with these pavements and the typical maintenance treatments that have been developed and employed.

Surface types at regional airports are influenced by the lower passenger and aircraft movement numbers, the often smaller aircraft size and the type of aircraft servicing these airfields. For example a number of regional airports will service only turboprop type aircraft such as the Beech 1900, Q300 and ATR-72. Typical airfield pavement surface types include the following:

Grass Runways – common only at small regional air strips or as an alternate runway surface for light General Aviation aircraft.

Chipseal Pavements – historically one of the more common pavement surface types around the regional airport network in New Zealand. The flexible aggregate pavement basecourses are sprayed with a bituminous prime coat before typically two coats of “chipseal” are applied. The chip is typically graded from 5 to 20mm and a tightly packed surfacing layer is formed for trafficking. This is an example of “roading” type pavements being adapted for light duty aircraft as an economic airfield surfacing and was originally used on a number of airfields in New Zealand. Currently, this is only likely to be used by turboprop type aircraft, and surface details are shown below from Hawke’s Bay (Napier) Runway 07-25 (refer to Figure 2).

Figure 2 - Hawke’s Bay (Napier) Runway 07-25 - Chip Seal Surface

Surface Rejuvenations – thin surface enrichment treatments are often applied to a pavement surfacing such as a chip seal pavement to extend the life of the surfacing. Typical treatments include slurry seal sprays up to 5mm thick and including a fine aggregate or sand, down to much finer treatments such as a SEST (Surface Enrichment Sprayed Treatment), Polymer Modified Emulsions, or proprietary treatments such as Pavecoat S ™ or Liquid Road ™. Other variations developed in New Zealand include a Cape Seal (a combination of chip seal and slurry seal – as used at Oamaru Airport in 2005) or a Sand Seal where a surface measure of fine sand is also spread.

Asphaltic Concrete – over the last ten years this has become the most common airfield pavement surface type in New Zealand and Asphaltic Concrete (AC) is used as a wearing course over a range of layered unbound or stabilised flexible aggregate basecourses. For most airfields the AC typically uses a stiffer 60/70 penetration grade bitumen with a softer 80/100 penetration grade bitumen more common in the southern half of the South Island. Polymer modified bitumens are gaining popularity though have not been used extensively. The attraction of AC at most airfields is primarily the lower capital cost compared to concrete pavements, together with the easier maintenance and replacement regimes at airfields with only one runway available.

Many variations of AC are to be found around the airfields in New Zealand, including conventional dense graded asphalt, grooved asphalt, variations of Superpave asphalt and Open Graded Porous Asphalt (OGPA) or Porous Friction Course. Dense graded asphalts are typically used at most major airports with Christchurch International Airport (Runway 02-20) and Wellington International Airport (Runway 16-34) having the only grooved runways. Elsewhere it has been found that the AC grading adopted has achieved the NZ CAA Advisory Circular AC139-13 (Reference 1) and ICAO Annex 14 Design Level friction values without grooving. Where adopted the grooving pattern is 6mm wide by 6mm deep at 38mm centres.

OGPA surface details are shown below from Hawke's Bay (Napier) Runway 16-34 (refer to Figure 3). Stone Mastic Asphalt has not been used to date on airfield pavements in New Zealand.

Figure 3 - Hawke's Bay (Napier) - Runway 16-34 – OGPA Surface

Figure 4 - Christchurch International Airport - Runway 02-20 - Grooved Asphalt Surface

Flexible pavements are typically designed with the Australian airport design system APSDS (Reference 2) and software available from the FAA (eg FAARFIELD and COMFAA (References 3 and 4)).

Portland Cement Concrete – Auckland Airport comprises largely Portland cement concrete pavements (up to 500mm thick PCC on compacted aggregate base) for the airfield runway and taxiway network, together with the various domestic and international apron stands. This is the only such airfield pavement network in New Zealand, primarily due to the relatively high cost of cement and therefore concrete in New Zealand, and the relatively lower number of aircraft movements at the majority of airports other than Auckland, making the additional cost of concrete hard to justify. Concrete pavements are used on a number of aircraft parking stands at other larger airports and regional hubs. At smaller regional airports it is common to have a small number of concrete slabs (with thicknesses of between 250 and 300mm PCC) under the positions of nosewheel and main gear wheels once the aircraft has parked at the gate.

The concrete pavements are typically placed manually and on a reasonably thick aggregate base course compared to some US airport designs. Jointing systems include keys, dowels and the usual array of expansion and construction joints. Concrete joints are typically sealed with a hot applied fuel resistant sealant. Concrete pavement design tools include a number of design charts, elastic layered software and the suite of design software available from the FAA and APSDS (Reference 2). Typically, 28 day concrete flexural strengths achieved are above 5MPa (725psi).

Interlocking Concrete Block Pavements – over the last few years the use of Interlocking Concrete Block Pavements (ICBP) on airfields in New Zealand has progressed as an economical alternative to PCC pavements. To date this has been limited to use at aircraft parking stands at Christchurch International Airport (International Stand 27 and Stand 34/35). The blocks have been laid on a 20mm thick layer of bedding sand on a cement stabilised basecourse layer with the blocks being sealed. To date the pavements are performing well under loading from Code E derivative aircraft.

Figure 5 - Christchurch International Airport - ICBP Under Construction

TYPICAL NEW ZEALAND AIRFIELD PAVEMENT DEFECTS AND MAINTENANCE TREATMENTS

The airfield pavement defects and maintenance treatments adopted are not unique to the New Zealand situation, however, a brief commentary is included within this paper for completeness.

The flexible pavement surfaces have tended to exhibit the following defects as both aircraft traffic and environmental degradation take their toll: lichen and weed growth (particularly on the edges of pavements); weathering, staining and loss of surface aggregate; open construction joints and parallel cracking of joints; longitudinal, transverse and block fatigue cracking; pumping and staining of surface; localised groove closure; localised bleeding, stripping, surface blisters; rubber deposits; shunting (or shoving); surface depressions and rutting; aircraft and fuel damage.

Maintenance treatments have included surface enrichment spray treatments with polymer emulsions (such as Pavecoat S), hot applied crack bandage sealing, slurry type seals, asphaltic concrete patching, asphaltic concrete milling and replacement and eventually construction of asphaltic concrete overlays.

Rigid concrete pavements have tended to exhibit the following defects: scaling, polishing (loss of surface texture); joint spalls, corner cracks and drying shrinkage cracks; fatigue cracking, secondary cracking and major spalls; loss and aging of sealant (cork and elastomeric products); settlement and pumping. Maintenance treatments have included crack sealing and bandaging, spall repairs using flexible material, epoxy injection and eventually slab replacement.

To date very few defects have been noted on the ICBP pavements at Christchurch International Airport, however longer term defects are expected to include cracked blocks (due to damage from jacking loads), loss of jointing sand, localised surface depressions and stepping.

PAVEMENT MANAGEMENT AND EVALUATION

Typically New Zealand (and Australia and the Pacific Islands) airport operators employ specialist consultants to undertake annual airfield pavement maintenance inspections, evaluate Pavement Classification Numbers (PCN) and develop long term Airfield Pavement Maintenance Plans to satisfy the requirements of the New Zealand CAA.

The airfield pavement management systems adopted are often relatively simple. The process may consist of a two man team undertaking a walking visual inspection (ideally in day light hours) recording distress types and their severity and establishing a surface condition rating. The rating system adopted is a simple and subjective system (as well as being economical) and is intended to provide a comparative rating of the surface condition of the pavement. The rating systems have no direct comparison to other systems such as the US FAA PASER rating system (Reference 5) or the more “sophisticated” Pavement Condition Index (PCI) rating system (Reference 6).

Airfield pavement strength evaluations and PCN assessments have been undertaken at the majority of airfields in New Zealand using either Benkelman Beam or more lately Falling Weight Deflectometer (FWD) deflection testing coupled with pavement coring, subgrade testing and subsequent analysis with APSDS and US FAA software.

INNOVATION AND SUSTAINABILITY

The relatively low population provides an associated challenge with the economic setting for the country and therefore the available funds for infrastructure investment; this together with the clean green image of New Zealand has led to a number of innovative and sustainable airfield pavement solutions being sought and adopted. A number of these innovations have centered around the concept of recycling the materials already found on the airfield sites. For example, this has included crushing old concrete slabs for re-use as aggregate materials at a number of locations, and also the re-use of asphalt millings in Recycled Asphalt Pavement (RAP).

Other innovations have included using lower grade materials either found on site or nearby. For example insitu subgrade materials have been stabilised with both cement and lime to improve their base performance. Lower grade scoria aggregates commonly found in the volcanic Auckland area have been used as either lower grade sub- basecourse materials, or again stabilised with cement to improve their performance.

Specialist plant and equipment is not always available in a ‘small’ country such as New Zealand at the end of the world. For example some large gantry equipment common for concrete slab removal can not be justified for a single concrete pavement network at Auckland Airport, so new methodologies have had to be developed. This has included modifying large mining construction plant with custom forks and using these overgrown forklifts to lift and remove the concrete slabs as shown in Figure 6.

More recently environmental sustainability has come to the fore and the adoption of low energy solutions are now often required. On the pavement front this has included the trial use of low temperature (warm mix) asphalt, together with recycled cooling water and other energy saving devices. Some of these innovative projects are described in more detail in the two case histories featured in the following section of this paper.

Figure 6 – Concrete Slab Removal with Modified Mining Equipment at Auckland Airport

AUCKLAND AIRPORT – A HISTORY OF INNOVATIVE PAVEMENT MAINTENANCE AND PAVEMENT REHABILITATION

Auckland Airport is the largest airport in New Zealand with over 155,000 aircraft movements and 13 Million passengers per annum. The airport is owned and operated by Auckland International Airport Ltd (AIAL). The airport has completed a number of pavement rehabilitation projects over the last 15 years, with a capital value of over NZ$100 Million.

The original concrete pavements at the airport were built in the 1960's and vary in thickness from 305 to 355mm PCC (12 to 14 inches), constructed over various aggregate layers including volcanic scoria hardfill. The original pavement design was based on a theoretical aircraft similar to the Boeing 707 operating at that time, but with approximately double the wheel load. The original design life was 20 years, and so by the 1990's the pavements had reached the end of their design lives and were exhibiting signs of fatigue distress. Defects typically included longitudinal full depth fatigue cracks, surface spalling along cracks, joint spalling and the development of secondary transverse fatigue cracks and spalls.

In the early 1990s, an assessment was made of the condition of the runway pavements and appropriate maintenance solutions were recommended to keep the airport operational. This was the start of a long term maintenance contract that has built trust and business understanding and in doing so has provided the freedom to develop innovative pavement engineering solutions not always normally possible within the consulting engineering framework. A categorisation system and database was developed for recording pavement defects and repairs that allowed a defect rating to be calculated and stored spatially. This system pre-dated many similar proprietary solutions and is still in use by the airport today to monitor pavement maintenance and manage expenditure and cashflow. Repairs typically include crack routing, sealing and bandaging, and sawcutting parallel to the cracks and backfilling with a shallow asphalt repair.

Conventional pavement reconstruction projects were completed using shortened runway operations at each end of the runway, but it was clear that the central portion of Auckland Airport's single runway posed a more serious problem - it could not be closed. Auckland Airport funded a two year research programme into state of the art epoxy underslab injection to support the failed concrete pavement slabs and defer the time until replacement was ultimately required. This involved laboratory trials, full scale dynamic testing and finally field trials before full scale implementation began in the mid to late 1990's at the airport.

The theory was to inject epoxy resin into the aggregates beneath the concrete slabs on either side of a longitudinal fatigue crack and form stiff bulbs of cemented aggregate. The spacing of the bulbs was designed so they would join together and form stiff beams running on each side of the crack and effectively provide edge support to allow the slab to perform as if not cracked.

A significant challenge was developing an epoxy that would form the required shape of bulbs. Too stiff and it would not permeate the aggregates, too thin and it would drain away to the base of the aggregates and achieve nothing. A number of epoxies were trialled for the particular aggregates used in the pavement construction at Auckland Airport, both in the laboratory and then in the field. Deflections were measured using a Benkelman beam on each side of the cracked slabs both before and after injection under a heavy static truck load. On average deflections were found to reduce by up to 15% after injection, and computer modelling confirmed this increase in stiffness and support would prolong the life of the cracked concrete slabs. A series of full scale dynamic trials were completed at the University of Auckland to confirm the durability of the materials and solution developed, with over 20,000 cycles of a Boeing 747 wheel load simulated without any significant increase in deflections.

This solution has been extremely successful and has deferred the time for replacement by an average of ten years. It has been used extensively at Auckland Airport and to this day provides a successful solution to defer the timing of major slab replacement projects until operations or economics suit. Of well over 1,000 slabs which have now been injected, only 6-7% of slabs with fatigue cracks have displayed signs of further deterioration and secondary fatigue cracking.

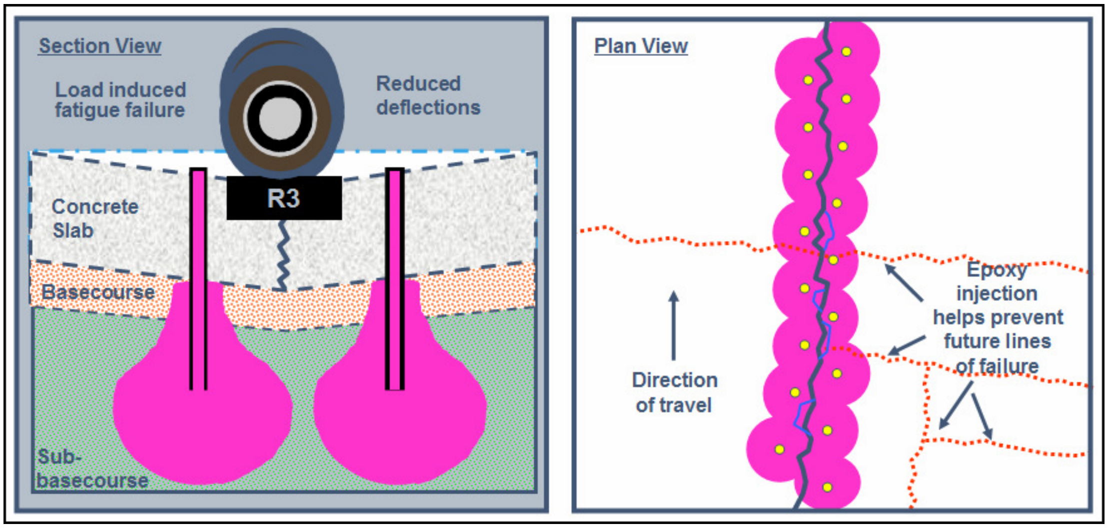

Figure 7. Cross Section and Plan Showing Concrete Pavement Epoxy Injection Concept

Figure 8. Epoxy Beams with Concrete Slabs Removed

The final section of runway replacement completed under shortened runway restrictions led to the development of a high strength four day concrete mix design by Firth Industries Ltd to target average flexural strengths of 5.3MPa with no individual results below 4.8MPa (700 psi). Key mix design parameters included 1100kg coarse aggregates, 450kg fine aggregate, 300kg sand, over 400kg cement and a water to cement ratio of approximately 0.4. Small quantities of water reducing and air entraining admixtures were also used. Typical concrete test results from laboratory and field trials and from construction field production are provided in Table 2 below.

Table 2.
Typical Concrete Mix Trial and Production Test Results

Test Age	Trial Cylinder Compressive Strength (MPa)	Test Cores Compressive Strength (MPa)	Field Compressive Strength (MPa)	Trial Beam Flexural Strength (MPa)	Test Beams Flexural Strength (MPa)	Field Flexural Strength (MPa)
4 Days	38.0	43.4	42.0	4.8	6.1	5.5
7 Days	46.5	-	-	5.4	-	-
28 Days	56.0	-	56.0	6.1	-	6.3

A research project was also undertaken to develop local relationships between concrete curing temperatures and flexural strength gains. After extensive laboratory and field trials it was concluded that approximately 2,000 cumulative °C–hours would result in insitu concrete flexural strengths above 5MPa. This led to the use of thermal temperature monitoring during construction and the approval to open the runway after only two days curing thereby completing the critical project ahead of programme. Results from construction thermal monitoring are shown in Figure 9 below, with the 2,000 cumulative °C–hours achieved after less than 48 hours.

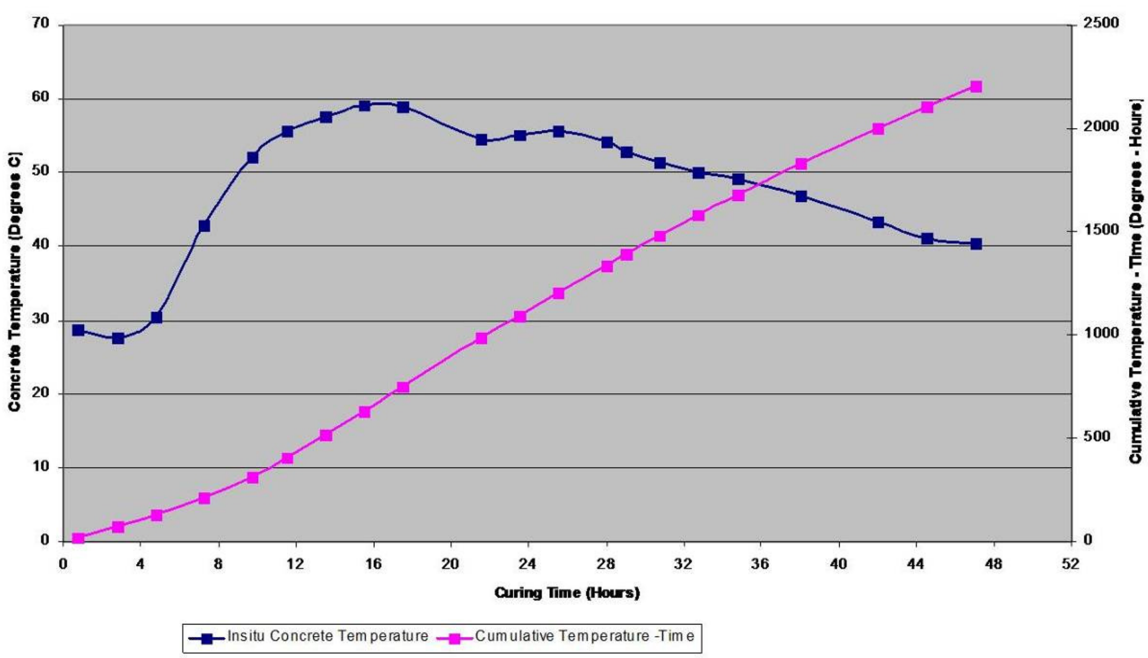

Figure 9. Construction Thermal Monitoring Results

Alternative solutions to replace the central runway sections were studied and the concept of converting the airport's parallel runway into a fully functional temporary runway was developed. Constructed through 2000 and 2001, the project involved the following scope of works: the parallel taxiway was strengthened and widened from 23m to 45m; additional inner parallel taxiways were constructed to provide access to the ends of the new temporary runway; a new approach lighting system was constructed and runway lighting and marking applied to the taxiway.

The stand-by Runway 05L-23R was first used in April 2002 for the R3 Reconstruction Project. All airport operations were diverted to the temporary runway for a period of 23 days and the original runway closed for reconstruction. The project was considered to be a huge success and was noted by the airport to be the longest use of a stand-by runway in the southern hemisphere, if not the world. The temporary runway was used again each year until the runway reconstruction was completed in 2006.

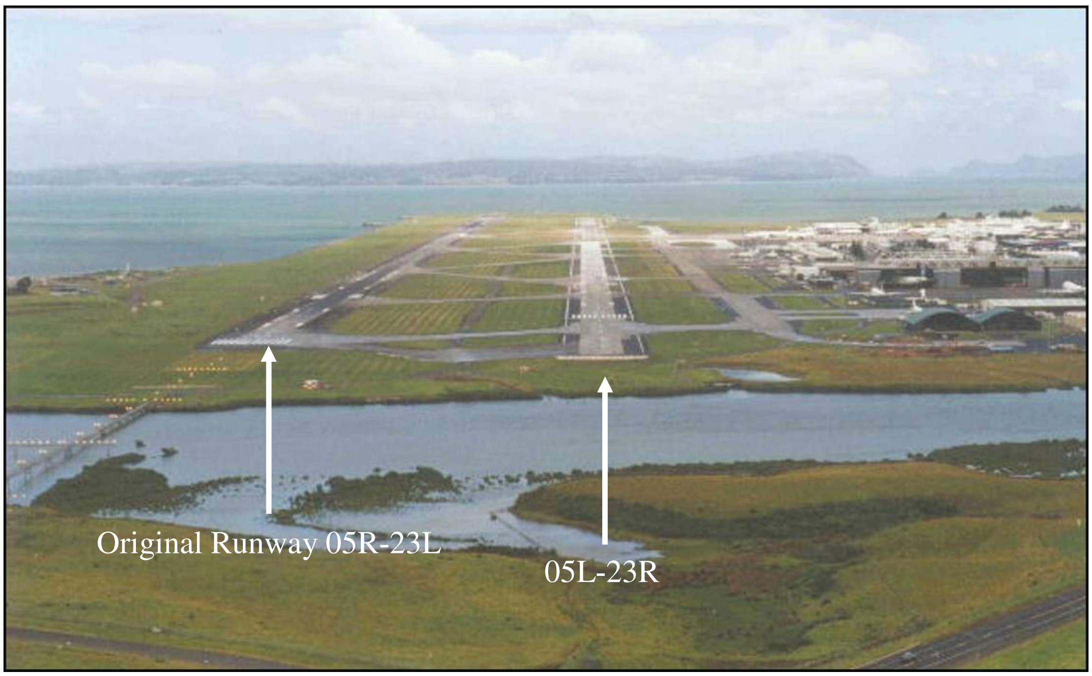

Figure 10. The Completed Temporary Runway 05L-23R

Many other technical innovations have been developed as part of these projects. Concrete recycling has been a feature of the projects and all old concrete slabs are now crushed for recycled use in other pavement structures at Auckland Airport. Specifically designed hydraulic activated blast fences have protected workers whilst improving aircraft taxiing operations. Airfield lighting bases have been buried beneath the pavements to enable continuous concrete paving, later drilling through the concrete at pre-set locations to uncover the light bases. The modified mining front end loaders mentioned earlier in this paper were trialled as an efficient method of removing the old concrete slabs quickly and have now improved the productivity of this operation by over 600%.

CHRISTCHURCH INTERNATIONAL AIRPORT – AIRFIELD PAVEMENT MAINTENANCE AND REHABILITATION WORKS 2005 TO 2010

Christchurch International Airport is the second largest airport in New Zealand with over 135,000 aircraft movements and six Million passengers per annum. The airport is owned and operated by Christchurch International Airport Ltd (CIAL). CIAL undertakes an annual programme of planned Airfield Pavement Maintenance Works (APMW) with a capital value of the order of NZ$5 Million and the works are usually programmed in New Zealand's summer between January and April each year to take maximum benefit of local weather conditions.

With the exception of a number of the International Aprons, the majority of the airfield pavements at Christchurch International Airport comprise a relatively thin asphalt surfacing (less than 100mm) on crushed gravel base and sub-base courses on a natural gravel subgrade. Over the last ten years with increasing aircraft masses and tyre pressures and environmental aging, the asphalt pavements have experienced a number of distresses including load induced cracking, shunting (or shoving), open construction joints and parallel cracking, surface attrition and localised rutting. In order to address these issues, a proactive approach to maintenance has been adopted using dense asphalt overlays as the preferred method for rehabilitating and strengthening the existing pavements.

Over the last five years, the physical works have comprised of the following:

- Runway 02-20 – Night time asphalt overlay of Runway 02 and a mill and fill of the central 16m width over a length of over 900m with 75 to 125mm of grooved asphalt (AC14 Mix).

- Runway 29 – day time overlay 100 to 125mm of AC14 asphalt using 15% to 30% Recycled Asphalt Pavement (RAP) on the outer edges of the runway and as regulating layers

- Resurfacing the full width of the main parallel taxiway, Taxiway A with asphalt (AC14 Mix) ranging in thickness from 50 to 115mm. Lengths of the shoulders and a 50m long section of the taxiway have been resurfaced with asphalt mixes containing 15% Recycled Asphalt Pavement (RAP). A 150 tonne trial using Coolpave Warm Mix asphalt was also undertaken on Taxiway A in 2008.

- Resurfacing of Taxiway F in 2009 with 100 to 125mm of AC14 and a 75m length with Coolpave Warm Mix and 15% RAP. A further trial of Coolpave low energy warm mix and 15% RAP on Taxiway A3 is being undertaken in January 2010.

- Reconstruction of Stand 27 and Stand 34/35 with Interlocking Concrete Block Paving (ICBP) which has proved to be a cost effective, less weather susceptible solution, with a shorter construction duration compared to traditional concrete construction for stand reconstruction works. To date the ICBP pavements have performed well.

The successful outcome of the projects over the last five years has collectively been attributed to the collaborative approach adopted and the positive energy expended by the Client (CIAL), Contractor (Fulton Hogan) and Consultant (Beca) team. From project learning, through risk and value management, to the highly proactive resolution of issues arising on site - these have instilled a sense of ownership and achievement and ensured a positive outcome for all parties. The key features of the APMW projects has been to safely and cost effectively implement the annual pavement maintenance works whilst implementing a number of airfield paving innovations and minimising disruption to airfield operations.

Environmental considerations have been addressed at all stages of the projects including:

- Environmental objectives set for the project
- Meeting CIAL's environmental goals (the Southern Hemisphere's first CarboNZero airport)
- Use of recycled materials and low energy asphalt on airfield pavements
- Minimal impact on airport neighbors
- Establishment of Environment Management Plans.

Figure 11 - Christchurch International Airport – Taxiway A Asphalt Works

One of the innovations adopted in 2008 was the use of Recycled Asphalt Pavement (RAP) in the asphaltic concrete on Taxiway A. Approximately 2,000 tonnes of asphalt with RAP at replacement level of 15% was used on the shoulders of and on a limited trial over the full width of the taxiway. This resulted in the saving of approximately 300 tonnes of new aggregates and bitumen. Whilst there are additional costs in the slightly higher production temperatures and in transporting the asphalt millings from the airport to the mixing plant, an approximate saving of the order of NZ$10,000 was achieved on the 2008 project. In both 2009 and 2010, with growing confidence in the use of RAP, areas of pavements have been laid with RAP levels up to 30%. Further laboratory testing will be undertaken to explore the use of RAP levels of 50 to 90% over the next two years. The use of RAP on airfield pavements in both New Zealand has been limited to date and the works at Christchurch International Airport are presently leading the way.

The laboratory and field results of the RAP mix have been found to be less consistent than the "traditional" asphalt mix without RAP due to the lower workability of the RAP mix and its tendency to cool more rapidly. To improve the workability of the RAP mix; the mix was originally heated to a higher temperature (by 10ºC (50ºF)) which helped maintain the workability and achieve compaction and more recently, a softer bitumen (80/100 pen) has been used. Some of the laboratory test results for increasing percentages of RAP are contained in Table 3 below.

Table 3.
Typical Laboratory Results of Asphalt Mixes

Mix	Bitumen Content % (Bitumen Film Thickness – microns)	Stability (kN)	Flow (mm)	Resilient Modulus (MPa)	Wheel Tracking (60ºC - 20,000 passes)	Tensile Strength Ratio (%)	Gyratory Voids at 85 cycles (%)
AC14	5.4 (9.5)	14.5	3	3,500	2.9	80	2.8
AC14 with 15% RAP	5.3 (9.3)	18	3	5,000	1.0	100	-
AC14 with 30% RAP	5.4 (8.9)	17	3	5,100	< 1.0	93	-

In 2008 a further innovation was a trial using 150 tonnes of Fulton Hogan's Coolpave low energy/warm mix asphalt on Taxiway A. The trial was undertaken adjacent to the centreline of Taxiway A over a length of approximately 100m. The patented technology (LEA Co system) allows the production and laying of most types of asphalt at temperatures under 100°C (212°F) without changing binder properties or aggregate gradings benefiting the works by reducing energy costs (with less fuel used in production by approximately 40%), resultant lower emissions and safer use without the loss of long term performance. A detailed monitoring regime (including insitu voids, texture depth and resilient modulus) of the trial section of Coolpave and the adjacent standard "hot mix" pavement was initiated during the first year of operation. Results of the Coolpave trial have been encouraging to date though the initial stiffness of the mix is lower than "traditional" mixes (see Table 4) and more compactive effort appears to be required. Further trials were undertaken recently on Taxiway F on Taxiway A3. Trials have also been undertaken with a combination of RAP and warm mix asphalt. The RAP and Coolpave mixes have both performed well to date.

Table 4.
Typical Field Results of Asphalt Mixes

Mix	Modulus (MPa) at 4 Weeks (cored specimen)	Modulus (MPa) at 1 Year (cored specimen)
AC14	2,400	2,900
AC14 with Coolpave	2,000	2,500
AC14 with 15% RAP	3,500	4,200

The use of warm mix asphalt on airfield pavements in New Zealand (and Australia) has been limited to date and the works at Christchurch International Airport are presently leading the way. In time and subject to ongoing trials and monitoring and satisfactory performance, it is anticipated that the ongoing use of RAP and Coolpave warm mix asphalt technology will, where appropriate, result in the use of less energy and virgin aggregate and provide overall cost savings for airfield maintenance projects.

SUMMARY AND CONCLUSIONS

This paper presents a summary of the range of pavement surface types found at airports throughout New Zealand, at both large international airports and across the network of smaller regional airports. The pavement surface types, typical defects and maintenance regimes are discussed.

The relatively low population leading to lower aircraft movements and funds for infrastructure investment combined with the clean green mentality New Zealanders are famous for has resulted in a real drive for innovative and environmentally friendly airfield pavement solutions.

The general discussion and case studies presented demonstrate that there are clear and tangible benefits to this approach to airfield pavement design, combined with recommending a focus on overall project team collaboration and successful project outcomes.

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